Microbiology (2) (205 M) Bacteria
Chemical composition of bacterial cell

By

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- At the end of this lecture the student must able to:
- 1- describe the structure of pili, plasma membrane, mesosomes, chromatin bodies, plasmids and the protoplast.
- 2- discuss the functions of pili, plasma membrane, mesosomes, chromatin bodies, plasmids and the protoplast.
- 3-compare the different types of plasmids.
- 4-describe the importance of plasmids for the bacterial cells.

Lecture 5

- The Contents
- 1- Structure and functions of pili.
- 2- Structure and functions of plasma membrane.
- 3- Habits and functions of mesosomes.
- 4- Characterization and functions of bacterial chromatin bodies.
- 5- Description and functions of plasmids.
- 6- Structure and functions of protoplast.

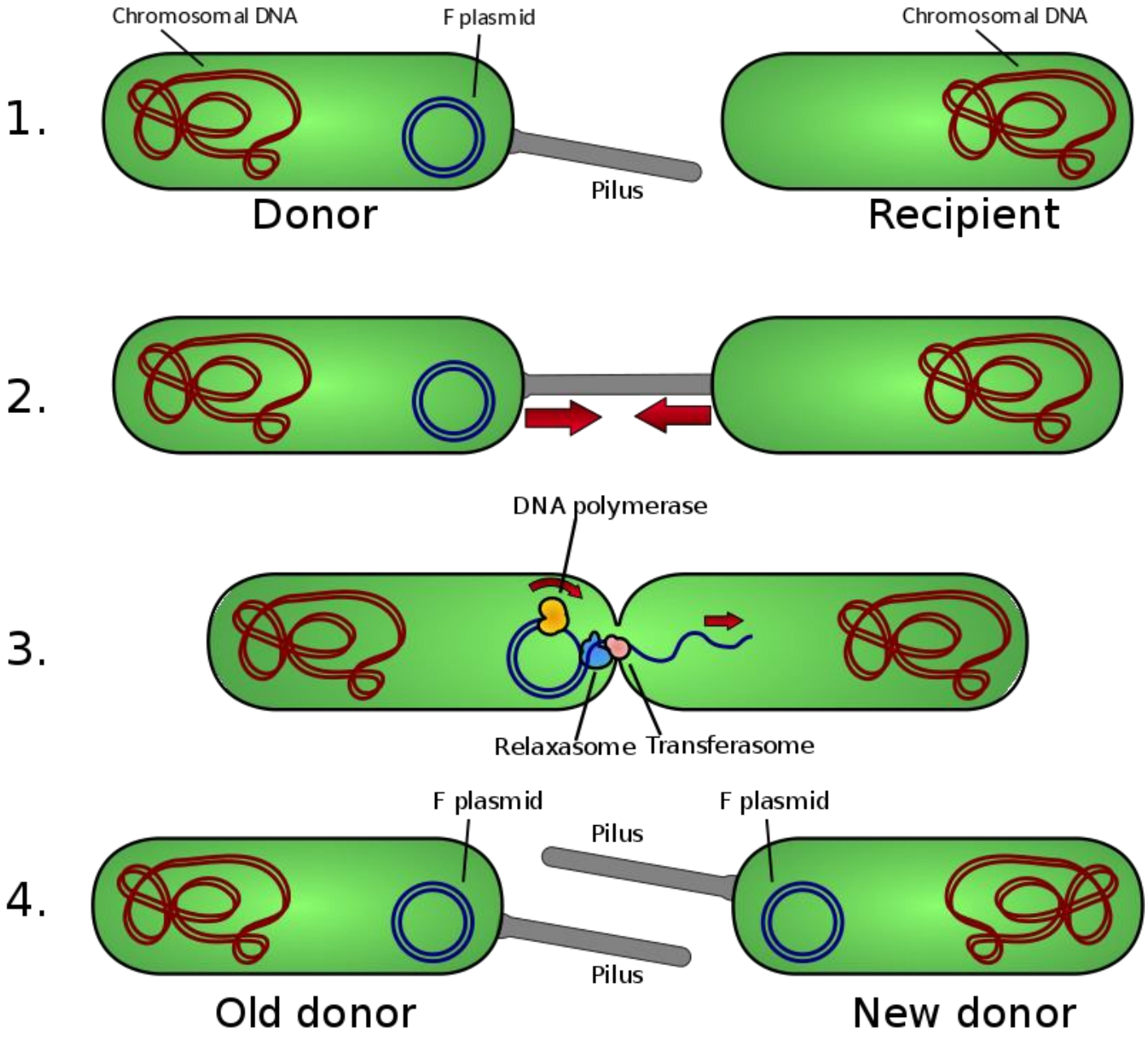
Pili

- **Bacterial pili (Latin: pilus, hair), some times called fimbriae, are morphologically distinct, nonflagellar appendages, found particularly on gram-negative bacteria freshly isolated from natural sources such as infected urine.**
- **Like flagella, they are too slender to be seen by ordinary light microscopy; most pili are 0.003 to 0.007 um in diameter**

- **They vary from 0.5 to 6 um in length, and certain pili are as long as 20 um. They are some appear to be rigid. One hundred to 400 are usually distributed over the cell surface.**
- **There are several types, which differ in size and structure. Mechanical agitation in a high-speed mixer remover them from the cell, and they can be purified by precipitation and centrifugation to yield a protein, pilin, with a minimum molecular weight of about 17,000.**

- **A pilus is composed of pilin subunits arranged in a very precise helical structure to form a smooth tube around a longitudinal hole.**
- **Physical, chemical, and genetic study has shown that one type of pilus is intimately concerned in the process of sexual mating, and probably provides the channel through which DNA from the donor (male) cell is transferred to the recipient (female) cell.**

- **Another type of pilus enables the organism to adhere to erythrocyles and other cells,**
- **and another enhances growth when the oxygen supply is limited and the cell population is high, perhaps by mediating the transport of some metabolite. The functions of other pili are not known.**


1.
Chromosomal DNA
F plasmid
Pilus
Chromosomal DNA
Donor
Recipient
2.
3.
DNA polymerase
Relaxasome
Transferasome
4.
F plasmid
Pilus
F plasmid
Pilus
Old donor
New donor

- Schematic drawing of bacterial conjugation. **1-** Donor cell produces pilus. **2-** Pilus attaches to recipient cell, brings the two cells together. **3-** The mobile plasmid is nicked and a single strand of DNA is then transferred to the recipient cell. **4-** Both cells recircularize their plasmids, synthesize second strands, and reproduce pili; both cells are now viable donors.

Plasma membrane

- **Protoplast (plasma) membranes are 5 to 8 nm thick and constitute 10 to 20 per cent of the dry weight of the cells. They are composed largely of lipoprotein and contain many enzymes, especially those concerned in biologic oxidations, by which the cell secures energy.**

- **The plasma membrane is a discrete, differentiated outer layer of the cytoplasm just beneath the cell wall. It stains intensely with basic dyes and is said to form the highly reflective layer observed in darkfield preparations.**
- **The plasma membrane is a membrane of the so-called unit type; that is, it is a three-layered structure consisting of a bimolecular "leaflet" of lipid between protein or other hydrophilic layers.**

- It **regulates the passage of materials into and out of the cell). Certain substances of low molecular weight, such as urea, glycine, and glycerin readily enter bacterial cells, whereas the electrolytes NaCl and KCl and larger organic molecules like glucose and sucrose traverse the membrane very slowly. The membrane is essentially impermeable to polar organic substances because of its high lipid content.**

- **Enzymes called permeases transport particular materials or groups of materials by forming easily dissociable complexes with them. The plasma membrane, together with the plasma membrane intrusions or mesesomes linked with it, comprises essentially a lipoprotein matrix upon which are organized most of the cytochromes succinoxidase and many other enzymes of the bacterial cell.**

Mesosomes

- They are invaginations of the plasma membrane in the shape of vesicles, tubules or lamellae. They are involved in cell wall formation during division, play a role in chromosomes replication and distibution to duaghter cells; involved in secretory process and help in respiration

Bacterial Chromatin Bodies (Nuclei)

- **Chromatin bodies are more-or-less centrally situated in resting cells and are spherical or oval or rod-shaped. During active growth they divide along the same axis as the cell, usually a little before cell division; sometimes two to four paired chromatin bodies can be seen in a single rod-shaped cell in the place of very rapid growth.**

- Size of chromatin bodies varies in dimensions among species and within the same species at different ages. Resting cells of one species of *Staphylococcus* possess chromatin bodies about 0.4 um in diameter, whereas in growing cells they enlarge to about 0.5 by 0.8 um. This structure constitutes 5 to 16 per cent of the cell volume. Chromatin bodies of resting E. *coli* occupy 15 to 25 per cent of the protoplasmic space.

- **Bacterial chromatin bodies appear to be composed of fine fibrils of DNA 0.3 to 0.4 nm in diameter.**
- **In gram-negative bacteria like *E. coli* and *Salmonella typhimurium* these fibrils are arranged in a delicate but compact whorl, whereas in gram-positive bacteria, such as various cocci and bacilli, the dense fibers are aligned in an almost parallel.**

- **The DNA constitutes a single chromosome, at least in the bacteria studied so far, and apparently a single two-stranded molecule about 1 mm. Long carries all the genetic information of the cell. The chromosome is an endless loop, and during replication it divides, but not by mitosis.**

- **New strands of DNA form, complementary in the usual way to each of those in the parent chromosome. The process begins at a certain place in the chromosome and proceeds around the molecule. At the fork in the chain there is presumably a swivel, which permits the parent helix to uncoil as the new strand is formed.**

Plasmids

- **A plasmid is a small DNA molecule that is physically separate from, and can replicate independently of, chromosomal DNA within a cell. Most commonly found as small circular, double-stranded DNA molecules in bacteria.**
- **In nature, plasmids can frequently be transmitted from one bacterium to another (even of another species) via horizontal gene transfer.**

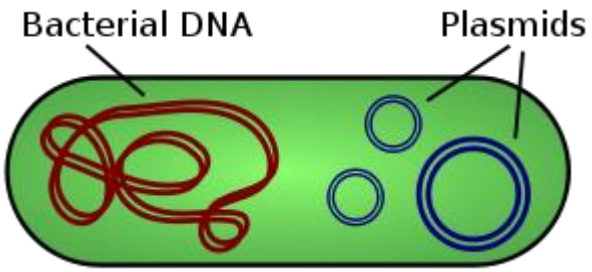
- **Artificial plasmids are widely used as vectors in molecular cloning. Plasmid sizes vary from 1 to over 1,000 kbp. The number of identical plasmids in a single cell can range anywhere from one to thousands under some circumstances. Plasmids carry genes that may benefit survival of the organism but not essential for growth.**

There are five main functions of plasmids:

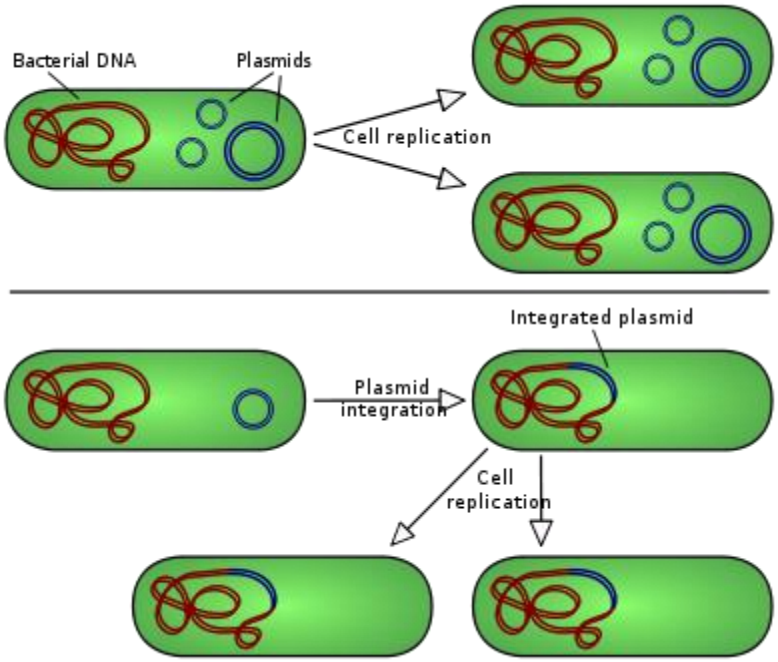
- Fertility F-plasmids, which contain tra genes. They are capable of conjugation and result in the expression of sex pilli.
- Resistance (R) plasmids, which contain genes that provide resistance against antibiotics.

- Col plasmids, which contain genes that code for bacteriocins, proteins that can kill other bacteria.
- Degradative plasmids, which enable the digestion of unusual substances, e.g. toluene and salicylic acid.
- Virulence plasmids, which turn the bacterium into a pathogen.

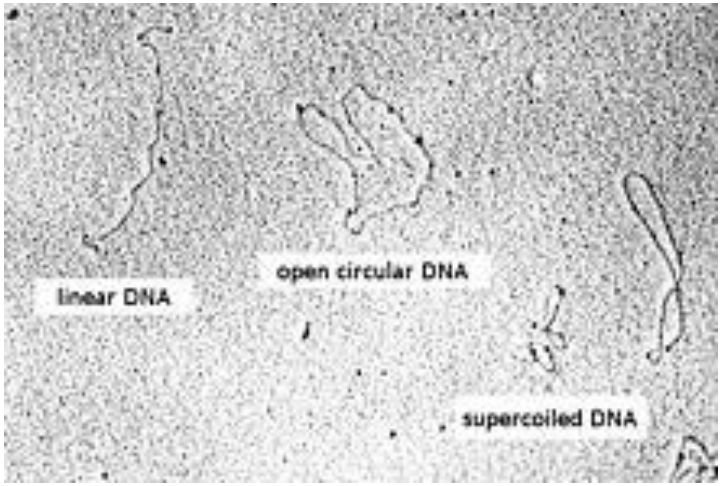
- Illustration of a bacterium showing chromosomal DNA and plasmids. Not to scale.



There are two types of plasmid integration into a host bacteria: Non-integrating plasmids replicate as with the top instance, whereas episomes, the lower example, can integrate into the host chromosome



Electron micrograph of a bacterial DNA plasmid (chromosome fragment)



The protoplast

- **The protoplast is that portion of the cell that is within the cell wall. The wall can be removed from cells of some species by treatment with the enzyme lysozyme, derived from egg white, tears or saliva. Lysozyme digests some of the complex polysaccharides in the cell wall.**

- **Certain organisms can also be made to grow without a wall in the presence of penicillin (which interferes with the formation of the glycosaminopeptide layer from its subunits), or by depriving them of diaminopimelic acid.**
- **A stabilizing agent such as 0.2 M sucrose must be present to prevent osmotic lysis.**

- **The resulting “naked” cells, which lack all traces of cell wall material, are called protoplasts; they are globular in shape and relatively stable, although much more sensitive to environment “discomforts” than intact cells. They are readily lysed by diluting with distilled water the stabilizing solution in which they are suspended.**
- Globular forms possessing partial or modified (e.g., by growth in penicillin or treatment with detergent) cell walls are known as spheroplasts.

- **Protoplasts perform most of the metabolic activities of whole cells, including energy yielding respiratory processes, synthesis of proteins, enzymes, and nucleic acids. They do not synthesize cell wall material, whereas spheroplasts can do so.**

- **This seems to indicate that the wall contains its own synthetic mechanism or that a "starter" or cell wall substance must be present before more can be laid down, protoplasts can grow and divide, and protoplasts of spore-forming bacteria prepared from cells that have taken the first steps toward sporulation can complete the process of producing spores. Protoplasts of motile organisms may possess flagella but are not motile.**

Questions

- 1-Describe in details the structures anf functions of each of the following:
- Pili, plasma membrane, protoplast, bacterial chromatin bodies.
- 2-Compare between the different types of plasmids.

References

1- Prescott, L. M., Harley, J. P. and Klein, D. A. (1993). Microbiology. 2nd edition. Wm. C. Brown Publishers, England.

2- Manosur, F.A. Principle of bacteriology. Mansoura University.

3-http:www.google.com (search for pili and plasmids, wikipedia)